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TITLE: SWITCHING DEVICE, OPTICAL SWITCHING UNIT AND VIDEO DISPLAY DEVICE

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ABSTRACT:

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SOLUTION: The semiconductor substrate 20 is constituted of a P type substrate 71, and a N type well 72 is patterned in a part corresponding to the arrangement of a lower electrode 8. The lower electrode 8 is connected with the N type well 72 through a connection electrode 13, an upper electrode 7 is grounded through a connection electrode 12 and electrically connected with the P type substrate 71. When a driver voltage is applied to the lower electrode 8, a depletion layer 79 spreads in the PN joint part 73 of the well 72 and the substrate 71, thereby forms capacitance having a sample-and-hold function.

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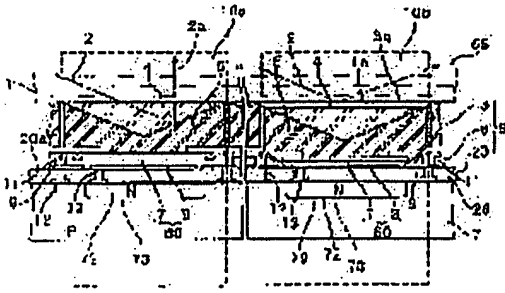
(54) SWITCHING DEVICE, OPTICAL SWITCHING UNIT AND VIDEO DISPLAY DEVICE



(57)Abstract:
PROBLEM TO BE SOLVED: To provide a device equipped with a sample-and-hold function which is compact and stores a driving signal in a switching device having an actuator for driving a switching part on a semiconductor substrate.
SOLUTION: The semiconductor substrate 20 is constituted of a P type substrate 71, and a N type well 72 is patterned in a part corresponding to the arrangement of a lower electrode 8. The lower electrode 8 is connected with the N type well 72 through a connection electrode 13, an upper electrode 7 is grounded through a connection electrode 12 and electrically connected with the P type substrate 71. When a driver voltage is applied to the lower electrode 8, a depletion layer 79 spreads in the PN joint part 73 of the well 72 and the substrate 71, thereby forms capacitance having a sample-and-hold function.

CLAIMS

[Claim(s)]
[Claim 1] The switching device with which it is the switching device which has a semi-conductor substrate, the actuator for a drive built on the front face of this semi-conductor substrate, and the switching section driven with this actuator, and at least one PN-junction section used as a reverse bias is formed between the fields where the path cord which supplies drive power to said actuator touches said semi-conductor substrate electrically.
[Claim 2] It is the switching device with which it is the electrostatic actuator by which the electrode pair for a drive by which the actuator for said drive was built on the front face of said semi-conductor substrate in claim 1 has been arranged, and at least one PN-junction section used as a reverse bias is formed between the fields where each electrode of said electrode pair touches said semi-conductor substrate electrically.
[Claim 3] It is the switching device which is the optical switching section driven in the location where said switching section turns on incident light with said actuator in claim 1, and the location to turn off.
[Claim 4] It is the switching device which is the optical switching section driven in the location which extracts the EBANE cent light to which said switching section began to leak from the total reflection side of lightguide with said actuator in claim 1, and the location which is not extracted.
[Claim 5] It is the optical switching section driven in the location which extracts the EBANE cent light to which said switching section began to leak from the total reflection

side of lightguide with said actuator in claim 2, and the location which is not extracted. It is the switching device which said electrode pair is equipped with the 1st electrode which moves with said optical switching section, and the 2nd electrode fixed to said semi-conductor substrate, and is formed so that, as for said PN-junction section, said 2nd electrode may enclose a wrap field for said semi-conductor substrate.

[Claim 6] It is the switching device which said switching section was driven almost in parallel to the front face of said semi-conductor substrate by said electrode pair, and said electrode pair is equipped with the 1st electrode which moves with said switching section, and the 2nd electrode fixed to said semi-conductor substrate in claim 2, and is formed so that, as for said PN-junction section, said 2nd electrode may enclose a wrap field for said semi-conductor substrate.

[Claim 7] The switching device which said two or more actuators are arranged in the shape of an array on the front face of said semi-conductor substrate, and said two or more switching sections drive with these actuators in claim 1, respectively.

[Claim 8] It is the switching device with which it is the electrostatic actuator by which the electrode pair for a drive by which the actuator for said drive was built on the front face of said semi-conductor substrate in claim 7 has been arranged, and at least one PN-junction section used as a reverse bias is formed between the fields where each electrode of said electrode pair touches said semi-conductor substrate electrically.

[Claim 9] It is the switching device which is the optical switching section driven in the location where said switching section turns on incident light with said actuator in claim 7, and the location to turn off.

[Claim 10] It is the switching device which is the optical switching section driven in the location which extracts the EBANE cent light to which said switching section began to leak from the total reflection side of lightguide with said actuator in claim 7, and the location which is not extracted.

[Claim 11] It is the optical switching section driven in the location which extracts the EBANE cent light to which said switching section began to leak from the total reflection side of lightguide with said actuator in claim 8, and the location which is not extracted. It is the switching device which said electrode pair is equipped with the 1st electrode which moves with said optical switching section, and the 2nd electrode fixed to said semi-conductor substrate, and is formed so that, as for said PN-junction section, said 2nd electrode may enclose a wrap field for said semi-conductor substrate.

[Claim 12] It is the switching device which said switching section was driven almost in parallel to the front face of said semi-conductor substrate by said electrode pair, and said electrode pair is equipped with the 1st electrode which moves with said switching section, and the 2nd electrode fixed to said semi-conductor substrate in claim 8, and is formed so that, as for said PN-junction section, said 2nd electrode may enclose a wrap field for said semi-conductor substrate.

[Claim 13] The optical switching unit which has a switching device according to claim 11 and said lightguide.

[Claim 14] The graphic display device which has an optical switching unit according to claim 13 and a means to output and input the light for a display to this optical switching device.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the switching device used for the graphic display device suitable for image projection equipment or image display devices, such as a data projector and a video projector, etc.
[0002]
[Description of the Prior Art] The thing using liquid crystal as a graphic display device which can carry out on-off control of the light as a light valve of graphic display devices, such as a projector, is known. However, the high-speed response characteristic of the graphic display device using this liquid crystal is bad, and it operates only with the speed of response which is an at most several mm second grade. For this reason, it is difficult for the equipment which displays the image of high resolution of which a high-speed response is required, and the switching device with which liquid crystal was further used for optical recording equipments, such as optical communication, optical operation, and a hologram memory, and an optical printer to realize.
[0003] Then, the switching device in which high-speed operation is possible or graphic display device which can respond to the above applications is called for, and development of the switching device equipped with the fine structure (micro structure) of micron order or still smaller submicron order is furthered wholeheartedly.
[0004]
[Problem(s) to be Solved by the Invention] One of them is a micro mirror device, and it supports a mirror possible [revolution] in York, changes the include angle of a mirror, modulates incident light corresponding to an electric or optical input, and it carries out outgoing radiation.
[0005] Moreover, it is possible to move the optical element equipped with the reflex function or the transparency function in parallel with an actuator, and to modulate incident light, and it is also possible to constitute the switching device (optical switching device) which turns into a graphic display device based on such a principle. total reflection of the light for which an applicant for this patent is applying is carried out, and the extract side of the switching section is contacted to the total reflection side of the light guide section which can be transmitted -- making -- EBANE cent light -- extracting -- the minute motion not more than about one wave or it of an optical element -- a high speed -- light -- a modulation -- a controllable optical switching device is also one of them.
[0006] The outline of a projector 80 is shown as an example of the graphic display device using the graphic display device (optical switching device) which performs switching by EBANE cent light to drawing 1 . This projector 80 is equipped with the source 81 of the white light, the rotation color filter 82 which decomposes the light from this source 81 of the white light into the three primary colors, and carries out incidence to the light guide plate (lightguide) 1 of the graphic display unit (optical switching unit) 55, the graphic display unit 55 which modulates and carries out outgoing radiation of the light of each color, and the lens 86 for projection which projects the light 85 by which outgoing radiation was carried out. And the light 85 which became irregular for every color is projected on a screen 89, and the image of the multicolor of many gradients is outputted

by carrying out color mixture in time. The projector 80 is equipped with the control circuit 84 which controls the graphic display unit 55 and the rotation color filter 82, and displays a color picture further. The image display unit 55 is constituted by lightguide 1 and the graphic display device (optical switching device) 50 explained in full detail below, and the data phi for displaying a color picture from this control circuit 84 etc. are supplied to the graphic display device 50.

[0007] Thus, the projector 80 shown in drawing 1 A means to output and input a light equipped with the lens 85 which projects the light by which outgoing radiation was carried out to the lightguide 1 transmitted while carrying out total reflection of the light from lightguide 1 with the light source 81 which supplies the light for projection, It has the graphic display device 50 which modulates the light for projection supplied to lightguide 1, and the EBANE cent light leaked from lightguide 1 with the graphic display device 50 is controlled, and an image is displayed.

[0008] The outline of the graphic display device (EBANE cent light switching device) 50 which modulates light to drawing 2 using an EBAN cent wave (EBANE cent light) is shown. The graphic display device 50 is a switching device with which two or more optical switching elements (optical switching device) 10 were arranged by two-dimensional, and alone, each optical switching element 10 carried out total reflection of the introduced light 2, it approached and deserted the light guide plate (lightguide) 1 which can be transmitted, and is equipped with the optical element (switching section) 3 which can modulate light, and the actuator 6 which drives this optical element section 3. And a laminating is carried out on the semi-conductor substrate 20 with which the drive circuit and digital store circuit (storage unit) where the layer of an optical element 3 and the layer of an actuator 6 drive an actuator 6 were made and jammed, and it integrates as one graphic display device.

[0009] It explains in more detail about the graphic display device 50 of this example which used EBANE cent light with reference to drawing 2 . When it explains based on each optical switching element 10, optical switching element 10a shown in the left-hand side of drawing 2 is an ON state, and optical switching element 10b shown in right-hand side is an OFF state. Field (contact surface or extract side) 3a which sticks an optical element 3 to field (total reflection side) 1a of a light guide plate 1 which achieves the function as waveguide, the evanescent wave which leaked and came out when this field 3a stuck to total reflection side 1a -- extracting -- the interior -- a light guide plate 1 -- receiving -- a cheek -- it has the support structure 5 which supports the reflecting prism (micro prism) 4 of the V character mold reflected in the perpendicular direction, and this V character type of prism 4.

[0010] the electrode pair which consists of an upper electrode (the 1st electrode) 7 which an actuator 6 is a type which carries out the electrostatic drive of the optical element 3, therefore is mechanically connected with the support structure 5 of an optical element 3, and moves with an optical element 3, and a bottom electrode (the 2nd electrode) 8 fixed to the semi-conductor substrate 20 in the location which stood face to face against this upper electrode 7 -- it has 60. Furthermore, the upper electrode 7 is supported from the anchor plate 9 with the stanchion 11 extended to the upper part, and also electrically, it touches while the upper electrode 7 is mechanically attached in maximum top-face 20a of the semi-conductor substrate 20 through the anchor plate 9. In the electrostatic actuator 6 equipped with one pair of electrode pair of such a bottom electrode 8 and the upper

electrode 7, space is formed among these electrodes 7 and 8. therefore, the plate 9 -- minding -- the upper electrode 7 -- grounding -- the bottom electrode 8 -- receiving -- the drive unit 21 to potential or a charge -- adding (it setting henceforth and being high potential) -- the upper electrode 7 moves caudad, this is interlocked with, and the optical element section 3 separates from lightguide 1 (the 2nd location). on the other hand, it has the function as an elastic member partially, and the potential or the charge currently added to the bottom electrode 8 from the storage unit 21 is removed, or the upper electrode 7 is canceled -- having (it setting henceforth and being low voltage) -- the upper electrode 7 separates from the bottom electrode 8, and the optical element section 3 sticks to a light guide plate 1 with the elasticity of the upper electrode 7 (the 1st location). of course, an electrode pair -- the bottom electrode 8 of 60 can be grounded and the optical element section 3 can also be driven by supplying potential or a charge to the upper electrode 7 from the drive unit 21.

[0011] As shown in drawing 2 , the illumination light 2 is supplied to the light guide plate 1 from the light source at the include angle which carries out total reflection by total reflection side 1a, light carries out total reflection to side 1a which faced, all the interfaces (optical switching section) 3, i.e., optical element sections, of the interior, repeatedly in an upper field (outgoing radiation side), and the interior of a light guide plate 1 is filled with a beam of light. Therefore, in this condition, macroscopically, the illumination light 2 was confined in the interior of a light guide plate 1, and has spread the inside of it without a loss [****]. On the other hand, microscopically, near field 1a which is carrying out total reflection of the light guide plate 1, the illumination light 2 leaked only a very slight distance of wavelength extent of light once from the light guide plate 1, and the phenomenon of changing a course and returning to the interior of a light guide plate 1 again has occurred. Thus, generally the light leaked from field 1a is called an evanescent wave. This evanescent wave can be taken out by making other optical members approach total reflection side 1a in wavelength extent of light, or the distance not more than it. The optical switching element 10 of this example is designed for the purpose of modulating namely, switching the light which transmits a light guide plate 1 using this phenomenon at high speed (turning on and off).

[0012] For example, in optical switching element 10a of drawing 2 , since an optical element 3 is in the 1st location in contact with total reflection side 1a of a light guide plate 1, field 3a of an optical element 3 can extract an evanescent wave. For this reason, an include angle is changed and the light 2 extracted by the micro prism 4 of an optical element 3 is set to outgoing radiation light 2a. And this outgoing radiation light 2a is used as a light 85 for the projection of the projector 80 shown in drawing 1 .

[0013] on the other hand -- optical switching element 10b -- the drive unit 21 -- an electrode pair -- the electrical potential difference on which a polarity differs from the above is impressed to the electrodes 7 and 8 which constitute 60, and it is moved to them in the 2nd location where the optical element 3 separated from the light guide plate 1 according to the electrostatic force committed among these electrodes 7 and 8. Therefore, by the optical element 3, an evanescent wave is not extracted and light 2 does not come out from the interior of a light guide plate 1.

[0014] Even when the optical switching element using an evanescent wave is independent, it functions as equipment which can switch light, but as shown in drawing 2 , it has in these-dimensional [1] or the two-dimensional direction, and composition that

can be further put in order and arranged to a three dimension. The image device or the image display unit 55 which can display a superficial image can be offered like liquid crystal or DMD by arranging a matrix or in the shape of an array to two-dimensional, and arranging to it especially. And in the graphic display device 50 using EBANE cent light, since the migration length of the optical element 3 which is the switching section serves as submicron order, it can use as light modulation equipment with a quick speed of response a single figure or more than it, and it becomes possible from liquid crystal to offer the image display device of the projector 80 in which the high-speed operation using this is possible, or a direct viewing type. Furthermore, the optical switching element 10 using EBANE cent light can turn light on and off about 100% by motion of submicron order, and can express an image with very high contrast. For this reason, it is easy to make time resolution high and the image display device of high contrast can be offered.

[0015] Furthermore, it is possible to offer the graphic display device 50 of a configuration of that the laminating of the actuator 6 and optical element 3 which have been arranged in the shape of an array was carried out to the semi-conductor accumulation substrate 20 with which the drive circuit etc. was made and jammed with this optical switching device 50 with one chip. That is, by assembling the graphic display device 50 and lightguide 1 which are the micro machine or integration device with which micro structures, such as an actuator 6 and an optical element 3, were built on the semi-conductor substrate 20, the graphic display unit 55 can be supplied and the projector as which a working speed is high resolving quickly, and can display the image of further high contrast can be offered by incorporating this.

[0016] the electrode pair which was equipped with the bipolar electrode 61 which moves among these in addition to the upper electrode 7 and the bottom electrode 8 as the actuator 6 of an electrostatic type was not limited to the thing equipped with the electrode of one pair of upper and lower sides of drawing 2 but was shown in drawing 3 -- the graphic display device equipped with the actuator 6 of a configuration so that 60 may be prepared, this bipolar electrode 61 may be interlocked with and an optical element 3 may drive is also possible. The graphic display device 50 using this EBANE cent light is equipped with the merit that it can drive by the low battery although the configuration of an actuator 6 becomes complicated. the electrode pair which consists of these three electrodes -- in the graphic display device 50 which adopted the actuator 6 equipped with 60, although there is a difference in control a little since the signal for a drive can be supplied not only to either of the up-and-down electrodes 7 and 8 but to the bipolar electrode 61 from the drive circuit 21, in the configuration which drives the optical element 3 which is the switching section by the electrostatic actuator 6, it is unchanging.

[0017] Furthermore, it is also possible to use the device which can supply driving force with other electrical signals, such as a piezo-electric element, and to constitute an actuator instead of the electrostatic actuator which used the electrode pair, and some things are considered as an actuator. Therefore, although it explains on these specifications hereafter based on the electrostatic drive type actuator of a vertical electrode since it is easy, the configuration of an actuator is not limited to this.

[0018] In the graphic display device 50, the optical switching element 10 shown in drawing 2 and drawing 3 R> 3 arranges in the shape of [, such as a three dimension,] an array to-dimensional [1] or two-dimensional, and a pan, and is arranged. For this reason,

as the drive unit 21 constituted by the semi-conductor substrate 20 is also shown in drawing 4 with these switching elements 10, it arranges a matrix or in the shape of an array to two-dimensional, and is arranged. Address signal phia is supplied in the direction of a train (the vertical direction of drawing 4) in order in these drive circuits 21 through the address line 44 which connected to juxtaposition the drive circuit 21 of the light modulation unit located in a line at the line writing direction (longitudinal direction of drawing 4) by the address-line driver circuit 45. Moreover, the data of each drive circuit 21 are supplied through the data line 41 which connected to juxtaposition the drive circuit 21 of the light modulation unit located in a line in the direction of a train by the data-line driver circuit 46. And data signal phid is latched to the drive circuit 21 which corresponds by address signal phia supplied synchronizing with data signal phid supplied to the data line 41, an actuator 6 drives by it, and on-off control of the incident light is carried out by the optical element section 3 which is the switching section.

[0019] Therefore, the storage element which holds supplied data signal phid is needed for the drive circuit 21 until a data signal is supplied to the following timing. The drive circuit 21 shown in drawing 5 (a) is a circuit using the capacity 22 inserted in an optical switching element 10 and juxtaposition as sample hold, on-off control of the switching element 23 which serves as the gate by address signal phia is carried out, and data signal phid supplied to suitable timing is held by capacity 22.

[0020] The drive circuit 21 shown in drawing 5 (b) is a drive circuit of two memory types proposed by the applicant for this patent. In addition to capacity 22, another memory is constituted by 1 set of inverters 24a and 24b with which this drive circuit 21 serves as the so-called circuit gestalt of SRAM and by which loop-formation connection was made. Therefore, data signal phid supplied by address signal phia from the data lines 41a and 41b is stored in the memory once constituted by Inverters 24a and 24b. Then, a switching element 25 operates by Junji Men signal phis supplied synchronizing with the rewriting timing of a frame etc., the capacity 22 and the optical switching element 10 whose data signal phid latched to memory is sample hold are supplied, and an optical switching element 10 drives by data signal phid.

[0021] Thus, it becomes possible [the drive circuit in which two storage elements were prepared can latch the data of the following image, while displaying the image, and] to rewrite the whole screen collectively with one clock. Therefore, in the image display device which displays multicolor with a color sequential method, the effectiveness of the use effectiveness of light improving is acquired and the image of bright high resolution can be displayed.

[0022] Even if it is the drive circuit of which type, since data signal phid is latched, the component or circuit which achieves a sample hold function is required, and the simplest sample hold is capacity. the optical switching element 10 using the EBANE cent light mentioned above -- an electrode pair -- it is also possible to have adopted the actuator 6 equipped with 60 and to use the parasitic capacitance of an electrode or wiring as a capacity for sample hold. However, it is difficult to secure capacity sufficient as sample hold. Moreover, although it is also possible to extend wiring or an electrode surface product like the image display device using liquid crystal, and to secure capacity sufficient as sample hold, those occupancy area becomes large too much and is not desirable. That is, as mentioned above, in spite of being able to offer it as a compact micro machine which carried out the laminating of an actuator and the optical element on

the semi-conductor substrate, if the optical switching element using EBANE cent light is designed so that capacity sufficient as sample hold can secure the area of an electrode or wiring, it becomes a size-limit and is not desirable.

[0023] Then, in this invention, it aims at offering the switching device which can include the capacity used as sample hold in a compact more in the switching device with which an actuator is constituted by the above on a semi-conductor substrate [like].

[0024]

[Means for Solving the Problem] For this reason, in this invention, the PN junction which functions on the semi-conductor substrate itself as sample hold is made paying attention to the above-mentioned switching device being built on a semi-conductor substrate. That is, the switching device of this invention is a switching device which has a semi-conductor substrate, the actuator for a drive built on the front face of this semi-conductor substrate, and the switching section driven with this actuator, and is characterized by forming at least one PN-junction section used as a reverse bias between the fields where the path cord which supplies drive power to an actuator touches a semi-conductor substrate electrically. By forming the PN-junction section used as a reverse bias in a semi-conductor substrate, the PN-junction section functions as a capacity and serves as sample hold. Therefore, it can prevent that the area in which it becomes unnecessary to arrange an electrode or wiring therefore in order to secure the capacity as sample hold, and each switching element occupies it increases.

[0025] Furthermore, the semi-conductor substrate used for the switching device concerning this invention is an IC substrate with which the circuit for driving an actuator was made. For this reason, the PN-junction section can be easily made from the process in which IC circuit is manufactured, only by carrying out patterning so that the conductor field where it differs for constituting the PN-junction section may be made in agreement with the layout of the actuator which is a superstructure. Therefore, space efficiency is good, and the device used as sample hold can be made from low cost to a semi-conductor substrate, and it can be crowded with it.

[0026] If the actuator constituted on a semi-conductor substrate drives with power, this invention is applicable to all types. If it is the electrostatic actuator by which the electrode pair for a drive by which the actuator for a drive was built on the front face of a semi-conductor substrate has been arranged, each electrode of an electrode pair should just form at least one PN-junction section used as a reverse bias between the fields which touch a semi-conductor substrate electrically.

[0027] Moreover, all the things to drive with actuators, such as a micro bulb, receive, and the switching section can apply this invention. Since the PN-junction section functions as sample hold, especially the device of this invention fits the device required to hold the condition of fixed time amount and the switching section. That is, this invention is equipped with the optical switching section which the switching section drives in the location which turns on incident light with an actuator, and the location to turn off, and is suitable for the optical switching device used for optical recording equipments, such as graphic display or optical communication, optical operation, and a hologram memory. As such an optical switching device, there is the optical switching section which was mentioned above and which is driven in the location which extracts the EBANE cent light which began to leak from the total reflection side of lightguide with an actuator, and the location which is not extracted.

[0028] When the electrode pair of an actuator is equipped with the 1st electrode which moves with the optical switching section, and the 2nd electrode fixed to the semi-conductor substrate, as for the PN-junction section, it is possible for the 2nd electrode to carry out patterning of the semi-conductor substrate so that a wrap field may be enclosed, and it can secure the area of the PN-junction section greatly in accordance with the layout of a switching device. Not only a switching device but the switching section using EBANE cent light drives almost in parallel to the front face of a semi-conductor substrate by the electrode pair, and a switching device equipped with the 1st electrode with which an electrode pair moves with the switching section, and the 2nd electrode fixed to the semi-conductor substrate can arrange the PN-junction section similarly.
[0029] Although the switching device of this invention may be a device with which an actuator and the switching section have been independently arranged on a semi-conductor substrate, two or more actuators are arranged in the shape of an array on the front face of a semi-conductor substrate, and it is possible to constitute the switching device which two or more switching sections drive with these actuators, respectively using IC substrate. Thereby, the device which displays images, such as two-dimensional or a three dimension, the device used for optical recording equipments, such as optical communication, optical operation, and a hologram memory, can be offered further. If it is the switching device which used EBANE cent light, by combining with lightguide, it can provide as an optical switching unit and graphic display devices, such as a projector, can be realized by combining with a means to output and input the light for a display to an optical switching device, further.
[0030]
[Embodiment of the Invention] With reference to a drawing, this invention is explained further below. The outline of the graphic display device (EBANE cent light switching device) 50 which modulates light to drawing 6 using the EBAN cent wave (EBANE cent light) concerning this invention is shown. The switching device 50 of this example is the configuration that are the switching device with which the optical switching element 10 which can extract EBANE cent light was arranged by two-dimensional, and the laminating of the layer of an actuator 6 and the layer of the gloss component section 3 was carried out on the semi-conductor substrate 20, like the optical switching device previously explained based on drawing 2 . Moreover, since the configuration of the optical element section 3 and the actuator 6 which constitute each optical switching element 10 does not change, these detailed explanation is omitted.
[0031] According to the layout of the bottom electrode 8, patterning of the well 72 of the N type with which the impurity of N type was introduced is carried out to the P type substrate 71, and, as for the semi-conductor substrate 20 of the switching device 50 of this example, the protective layers 26, such as silicon oxide or silicon nitride, are further formed in those front faces. the electrode pair which constitutes an actuator 6 -- among 60, it connects with the P type substrate 71 electrically through the stanchion 11, the anchor plate 9, and the connection electrode 12, and the upper electrode 7 is in the condition of having been grounded through the P type substrate or the connection electrode 12. On the other hand, the bottom electrode 8 is electrically connected to the N type well 72 through the connection electrode 13, and a driving signal is supplied by the drive circuit 21 by CMOS arranged to the interior of this well 72, or other fields.
[0032] Therefore, in the switching device 50 of this example, if high potential is

impressed to the bottom electrode 8 from the drive circuit 21 as shown in switching element 10b, while driving the optical element section 3 which is the switching section to the semi-conductor substrate 20 side and becoming off, the well 72 of N type will be in the condition that the reverse bias electrical potential difference was impressed to the P type substrate 71. For this reason, a depletion layer 79 is formed in the border area (PN-junction field) 73 of a well 72 and the P type substrate 71, and it functions as a capacity. Therefore, the capacity 22 which functions as sample hold shown in drawing 5 (a) or (b) made the switching device 50 of this example to the semi-conductor substrate 20, and it is full.

[0033] On the other hand, the condition which showed in switching element 10a will be in the condition that low voltage (touch-down potential) was impressed to the bottom electrode 8, and the optical element 3 touched lightguide 1, and will be held with the spring elasticity of the upper electrode 7. For this reason, the condition of switching is held until the driving signal with which that condition was memorized and the switching devices 50 of this example differed to that following timing once the driving signal was supplied is supplied.

[0034] The switching device 50 shown in drawing 7 is an example from which this invention differs, and patterning of the diffusion layer 75 of in all P molds is carried out to arrangement of an anchor plate 9 on the front face of the N type substrate 74 in the semi-conductor substrate 20 of this switching device 50. and the electrode pair which constitutes an actuator 6 -- among 60, the upper electrode 7 is electrically connected with the diffusion layer 75 of P type through a stanchion 11, an anchor plate 9, and the connection electrode 12, and the bottom electrode 8 is electrically connected with the substrate 74 of N type through the connection electrode 13. Moreover, the connection electrode 12 is grounded, and it is arranged by the connection electrode 13 so that the driving signal from the drive circuit 21 may be supplied.

[0035] Therefore, also in the switching device 50 of this example, if high potential is supplied to the connection electrode 13 from the drive circuit 21 in switching element 10b, a depletion layer 79 will be formed in the border area 73 of the P diffusion layer 75 and the N type substrate 74, and it will function as a capacity 22 used as sample hold.

[0036] The switching device 50 shown in drawing 8 is an example which is different in the pan concerning this invention, and is an example corresponding to the switching device previously explained with reference to drawing 3 . the electrode pair from which this switching device 50 constitutes an actuator 6 -- in addition to the upper electrode 7 and the bottom electrode 8, it has as 60 the bipolar electrode 61 driven among these. Although there are some control approaches of driving such an actuator 6, while impressing the bias voltage of high potential to the upper electrode 7 and carrying out low voltage (touch-down) of the bottom electrode 8, below, by supplying high potential and low voltage (touch-down potential) to a bipolar electrode 61 explains how to drive an actuator 6 to an example.

[0037] The N type substrate 74 is adopted and, as for the semi-conductor substrate 20 of the switching device 50 of this example, patterning of the diffusion layer 78 of P type is carried out to the location corresponding to arrangement of the bottom electrode 8. Moreover, patterning of the well 76 of P type and the diffusion layer 77 of the N type located in it is carried out to the location corresponding to arrangement of the upper electrode 7. And the upper electrode 7 is electrically connected with the diffusion layer

77 of N type through the connection electrode 12, and the bottom electrode 8 is electrically connected with the diffusion layer 78 of P type through the connection electrode 13. Moreover, a bipolar electrode 61 is connected with the substrate 74 of N type through the connection electrode 14, and a driving signal is further supplied from the drive circuit 21 through the connection electrode 14.

[0038] First, in the condition of switching element 10a, the same touch-down potential as the bottom electrode 8 is supplied to a bipolar electrode 61. Consequently, a bipolar electrode 61 is driven to the upper electrode 7 side according to electrostatic force. At this time, to the N type substrate 74 and the P type well 76 serving as forward voltage, the diffusion layer 77 of the P type well 76 and N type serves as a reverse bias, and a depletion layer 79 spreads in the PN-junction section 73 of these boundaries. Therefore, this depletion layer 79 serves as the capacity 22 which functions as sample hold.

[0039] In the condition of switching element 10b, the high potential same to a bipolar electrode 61 as the upper electrode 7 is supplied. Consequently, a bipolar electrode 61 is driven to the bottom electrode 8 side according to electrostatic force. At this time, the diffusion layer 78 of the N type substrate 74 and P type serves as a reverse bias, and a depletion layer 79 spreads in the PN-junction section 73 of these boundaries. Therefore, this depletion layer 79 serves as the capacity 22 which functions as sample hold. thus, the electrode pair for a drive -- even if it is the switching device equipped with the bipolar electrode 61 as 60, the capacity which functions as sample hold by the PN-junction section can be made to the semi-conductor substrate 20.

[0040] it was shown in these examples -- as -- the electrode pair of an actuator 6 -- by forming the diffusion layer or well of the suitable conductivity type for the field of the semi-conductor substrate which the electrode which constitutes 60 connects electrically, between the semiconductor regions which an electrode connects respectively, it connects with juxtaposition electrically to the pair of an electrode, and the PN-junction section 73 which serves as a reverse bias to driver voltage can be made. therefore, if driver voltage is impressed in the switching device 50 of this example, the capacity in which a depletion layer 79 achieves the function as breadth and sample hold will form in the PN-junction section 73 -- having -- driver voltage -- predetermined period maintenance -- it can carry out. Doping an impurity suitable on a semi-conductor substrate, and forming the diffusion layer of P type or N type is carried out to usual at the process which forms a CMOS-IC substrate, and although not illustrated to drawing 6 thru/or drawing 8 R> 8 in the semi-conductor substrate 20 of this example, it is an indispensable process for making the drive circuit 21. Therefore, it is easy to make the PN-junction section 73 which functions as sample hold to the semi-conductor substrate 20, therefore a man day hardly increases, and even if it increases, it will fit in the usual range as a process which manufactures a semi-conductor substrate. Furthermore, it is also possible to utilize effectively the well by which the CMOS circuit for constituting the drive circuit 21 is arranged, and to arrange the PN-junction section to inter-electrode, and sample hold can be made to a semi-conductor substrate, without increasing a man day and cost, if such patterning is adopted.

[0041] Furthermore, if the capacity which functions as sample hold by the PN-junction section is made to a semi-conductor substrate, in order to secure an equivalent capacity, it is not necessary to newly extend wiring area or to extend an electrode surface product. Therefore, it becomes possible to make occupancy area of each switching element 10 on a semi-conductor substrate into the minimum, and the switching device of high density

can be offered. And as shown in drawing 1 , it becomes possible by combining the switching device 50 of this example with lightguide 1 to offer the compact optical switching unit 55. Furthermore, the image display device which can display [that it is still compacter and] the good image of image quality can be offered by including this optical switching unit 55 in image display devices, such as a projector 80.

[0042] Moreover, when carrying out patterning of a diffusion layer or the well, the capacity which can be used as sample hold can be easily controlled by controlling those area and depth. In order to carry out long duration maintenance of the driving signal, it is desirable for the capacity which can be used as sample hold to be large, and it is desirable for the area of a well or a diffusion layer to be greatly securable for that purpose. The above-mentioned electrode pair as shown is adopted as a drive of an actuator, in the switching device which moves the optical element section 3 to the upper and lower sides or the 1st and 2nd locations as the switching section, one electrode is interlocked with the switching section, and moves, and the electrode of another side is fixed to the semi-conductor substrate 20. Moreover, in order to obtain predetermined driving force (electrostatic force) by these electrode pairs, a predetermined electrode surface product is required. Therefore, it becomes possible to form the diffusion layer of the area of this level on a semi-conductor substrate mostly with an electrode by carrying out patterning of the diffusion layer along with the electrode disposition of the side fixed to the semi-conductor substrate 20. For this reason, a big capacity which functions as sample hold simply, without increasing occupancy area is securable.

[0043] In addition, although this invention is explained above based on the example which grounded the upper electrode, or the example which supplies and drives driver voltage to a bipolar electrode, it is also possible to ground the bottom electrode fixed to a semi-conductor substrate, or to impress bias voltage to a bipolar electrode, and to drive with an upper electrode and a bottom electrode. It is possible to form the PN-junction section which serves as a reverse bias to driver voltage like the above by forming the diffusion layer of the suitable conductivity type for the front face of the semi-conductor substrate with which the semi-conductor substrate of a suitable conductivity type is chosen as these also by the case, and a connection electrode touches.

[0044] Furthermore, although this example explains to the example the optical switching device equipped with the optical element section as the switching section, this invention is applicable also to the switching device or micro machine which carried the switching section which achieves an actuator and other functions, for example, functions, such as a micro bulb, on a semi-conductor substrate. Moreover, an actuator may also be the type which drives the switching section not only using what adopted the electrode pair of this example and used electrostatic force but using a piezo-electric element or other piezoelectric devices etc. If it is an actuator using a piezo-electric element, the function which carries out sample hold like the above-mentioned example can be given by carrying out patterning of the PN-junction section to the connection inter-electrode for an output which impresses an electrical potential difference to a piezo-electric element.

[0045]

[Effect of the Invention] As explained above, the switching device of this invention is a switching device which has a semi-conductor substrate, the actuator for a drive built on the front face of this semi-conductor substrate, and the switching section driven with this actuator, and he is trying for the path cord which supplies drive power to an actuator to

form at least one PN-junction section used as a reverse bias between the fields which touch a semi-conductor substrate electrically. For this reason, in the switching device of this invention, the depletion layer produced in the PN-junction section can make it function as sample hold holding a driving signal, and can make a sample hold function in a compact in a semi-conductor substrate. Therefore, the thing which were equipped with the function to memorize a video signal etc. for every pixel, by this invention and for which the quick switching device of a working speed is offered becomes it is compact and possible, and optical recording equipments, such as equipment which displays the image of high resolution, optical communication, optical operation, and a hologram memory, and the still more suitable switching device for an optical printer etc. can be offered.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the outline **** Fig. of a projector using the graphic display device using EBANE cent light.
[Drawing 2] It is drawing showing the outline of a graphic display device (switching device) in which EBANE cent light was used.
[Drawing 3] It is drawing showing the example from which the switching device using EBANE cent light differs.
[Drawing 4] The drive circuit which drives the switching element of the graphic display device shown in drawing 2 or drawing 3 is drawing showing the condition of being arranged in the shape of an array.
[Drawing 5] It is an example of the drive circuit shown in drawing 4 , and drawing 5 (a) is the example of the drive circuit equipped with one memory, and drawing 5 (b) is the example of the drive circuit equipped with two memory.
[Drawing 6] It is drawing showing the outline of the optical switching device concerning the gestalt of operation of this invention.
[Drawing 7] It is drawing showing the outline of a different optical switching device from the above concerning the gestalt of operation of this invention.
[Drawing 8] It is drawing concerning the gestalt of operation of this invention showing the outline of a further different optical switching device.
[Description of Notations]
1 Light Guide Plate (Lightguide)
2 Illumination Light
3 Optical Element
4 Micro Prism
5 Support Structure of V Type
6 Actuator
7 Upper Electrode and Spring Structure
8 Bottom Electrode
9 Support
10 Optical Switching Element

11 Post (Stanchion)
12, 13, 14 Electrode for connection (path cord)
20 Semi-conductor Substrate
21 Drive Circuit
22 Sample Hold Component (Capacity)
50 Graphic Display Device
55 Graphic Display Unit
60 Electrode Pair
61 Bipolar Electrode
71 P Type Substrate
72 77 N type diffusion layer
73 PN-Junction Section
74 N Type Substrate
75, 76, 77 P type diffusion layer
79 Depletion Layer
80 Projector